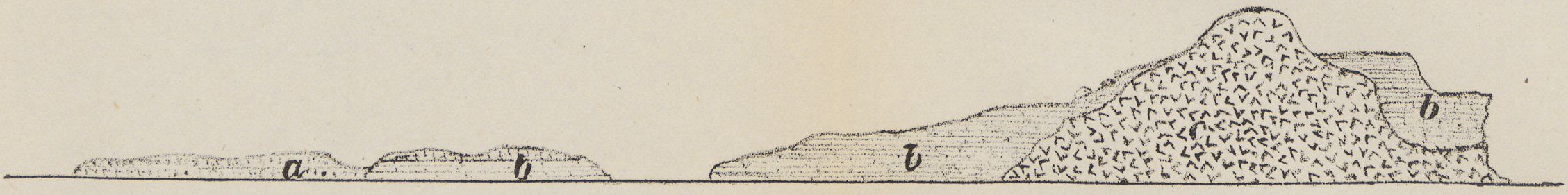


IDEAL SECTION,

ACROSS NORTH BRUNI FROM WOODCUTTER'S POINT TO VICINITY OF TRUMPETER BAY.

a. Brownish bedded Sandstones.

b. Fossiliferous Marine Beds, Up. Palæozoic.

c. Diabasic Greenstone.

There are two fine specimens in the collection of the Tasmanian Museum. The species is readily distinguished from C. tenuistrata, and other forms by its much wider apical angle. Dr. Waagen has recently figured a portion of a similar form from the olive group of the Salt Range, India, where it is associated with *C. lævigata* and *C. tenuistrata* as in Tasmania.

CONULARIA LÆVIGATA (Morris).

Shell smooth, elongate, pyramidal, rectangular, gradually decreasing; two of the faces larger than the other two; faces slightly concave, longitudinally sulcated at the lateral angles, ornamented with equal transverse ridges, forming a slightly obtuse angle in the mesial furrow, where they alternate with each other; ridges terminating at the bottom of the lateral channels, curving slightly upwards, and alternating with each other, producing a somewhat granulated ridge, apical angle very acute, not exceeding transverse, striæ simple, somewhat sharp, close, and regular—16 in the space of half-an-inch.

Locality. One imperfect cast from Upper Palaeozic limestones, River Styx, and occasionally found at Porter's Hill associated with *Spirifera convoluta*, *S. glaber*, *S. Tasmaniensis*, *S. duodecimo-costata*, and other well-known forms. Occurs also at Yass Plains, New South Wales.

NOTES ON THE GEOLOGY OF BRUNI ISLAND.

By Robt. M. Johnston, F.L.S.

[*Read April* 13, 1886.]

Bruni Island is separated from the mainland of Southern Tasmania by the tortuous course of D'Entrecasteaux Channel. Its greatest length—north and south—from Kelly's Point to Bruni Head is about 31 miles. Its breadth is extremely variable. A mere strip of sand over seven miles long divides Isthmus Bay on the western side from Adventure Bay on the eastern side, and the same narrow neck forms the junction between North Bruni and South Bruni. The breadth of North Bruni varies from five to seven miles, and the breadth of South Bruni varies from three to $10\frac{1}{2}$ miles.

This variation in breadth is caused by the deep and wide indentations of its numerous bays, among which may be mentioned—Barnes Bay, Great Bay, Isthmus Bay, Little Taylor Bay, Great Taylor Bay, Cloudy Bay, and Lagoon, Adventure Bay.

With the exception of Mount Bruni in the south, and associated greenstone spurs, there are no ranges of great altitude.

The characteristic vegetation is identical with that on the neighbouring shores of the mainland.

On the coast line and on open slopes we have the following shrubs and trees, namely :—*Casuarina quadrivalvis*, *Eucalyptus globulus*, *E. viminalis*, *Banksia marginata*, *Acacia melanoxylon*, *A. Riceana*, *A. verticellata*, *A. longifolia*, *A. mollissima*, etc.

In valleys, and especially in the deep ravines of South Bruni, exist *Eucalyptus gigantea*, *Pomaderris apetala*, *Fagus Cunninghami*, *Atherosperma moschata*, *Anopterus glandulosum*, *Lyonsia straminea*, *Aster argophylla*, *Phyllocladus rhomboidalis*, *Dicksonia antarctica*, etc.

Bruni Island in character and appearance seems to be a simple prolongation of that notable spur running southerly from the slope of Mount Wellington, and rising into remarkable prominences at Mount Nelson, Bonnet Farm, and Mount Pearson. Like the northern portion of this spur the fundamental rock of Bruni Island, here and there rising into bold crests as at Fluted Cape and Mount Bruni, is essentially a diabasic greenstone.

The eastern and western shores differ widely in character. Along the former the shoreline is generally bordered by bold cliffs, often exceeding 100 feet in height. Where there are no bays or deep indentations the faces immediately washed by the sea are composed of greenstone, which for the most part is overlaid by thin regular and almost horizontal stratified beds composed of the marine mudstones, limestones, and conglomerates of Upper Palæozoic age. In this respect the character of the cliffs is identical with that already described by me in a section of the coast line between Blackmans Bay and Pearson Point.

As might be expected the rocks within the bays are to a larger extent composed of the softer stratified layers, and, from this circumstance, they are less able to resist the destructive action of the sea waves. On the western coast line there are no cliffs or ridges of any great height with the exception of the coast line near Bruni Lighthouse, south of Great Taylor Bay. This is accounted for by the fact that the western coast is to a large extent composed of the softer rocks (sandstones and mudstones), and more particularly because, with the exception of the stratified rocks at Adventure Bay, the mudstones and sandstones slope to the west in the direction of the prevailing dip, which varies from 10° to 20° west, or west by south.

The general effect of this dip from east to west as affecting the respective coast lines is well illustrated by the stratified

rocky island of the Iron Pot, which exhibits the same character on a small scale.

The greenstone axes generally trend north and south, and the marine beds invariably quietly repose upon their bases, or abut against their slopes up to a height of from 300 to 400 feet. In the northern part of the island sandstones—red and brown—immediately succeed the mudstones, and correspond with them in the dip to the west. The position of these sandstones have not yet been ascertained satisfactorily.

Adventure Bay.

In Adventure, near Quiet Corner, the lower coal measures occur resting conformably upon the marine grits and sandstones of Upper Palæozoic age. There appears to be no stratigraphic break between the two groups. On the northern side the dip of these groups is from 10° to 15° due south.

In traversing the coast line from the Sandy Neck to Quiet Corner the following rocks crop up to the surface in stair-like ledges, remarkable for their regularity :—

		FOR ABOUT
1.	Marine gritty conglomerates and indurated sandstones and mudstones, in which there are at rare intervals thin bands containing the following fossils sparingly, viz.:—*Spirifera Strzelecki*, *S. Darwinii*, *Peterinea macropteras* silicified trunks of a fossil conifer of great size	1760 yards
2.	Similar beds, apparently devoid of fossils ...	880 „
3.	Band of indurated carbonaceous shales	12 „
4.	Laminated sandstones, white and red, with ripple marks	440 „
5.	Sandstones and black and grey carbonaceous shales	440 „
6.	Grey shales and laminated sandstones in their beds...	440 „
7.	Brownish coarse sandstones, with false bedding, evidently formed by Æolean agency	440 „
8.	Bosses of sandstones, at intervals similar to 7, but dipping more abruptly to the south-east...	
9.	Whitish sandstone, evenly and more horizontally bedded	440 „
10.	Long sandy beach, low-lying coast, continuing to Bennet's Corner, where the greenstone slopes of Fluted Cape are reached	

It is in the neighbourhood of No. 5 where the coal seam worked by Mr. Zschachner occurs. I was greatly surprised to find that the carbonaceous group at this place belonged to the lower coal measures, for the prevailing impression hitherto was that all the coal measures of the south and east

belonged to Mesozoic age. It is probable that the coal seam known to exist a little further to the south of the Arched Island is a member of the same group, as well as the coal seams occurring south of Port Esperance towards Whalehead. The true position of the coal measures was first suggested to my mind by the intimate stratigraphic relations which subsisted between the members of the coal measures and the underlying marine beds.

This supposition was afterwards confirmed by my discovery of well-known lower coal measure plants, which appear to be restricted to two very thin bands of dense carbonaceous shale situated immediately above and below the seam of coal now being worked.

The following is a list of all the plants observed by me.

1. Gangamopteris spathulata.
2. „ obliqua.
3. Glossopteris Browniana, var. praecursor.
4. Portion of a fruit with inbricate scale impressions of irregular pentagonal form.
5. One or two fruits identical with forms common in the Mersey coal shales.
6. One specimen of a large fruit.
7. Impressions of various fern-like stems.

These plant impressions are abundant in the two bands of shale already referred to, but I could not succeed in tracing any plant impression in the laminated shales—grey and black—so largely developed above and below the margin of the coal seam, and extend for about a mile along the shore some distance north of Quiet Corner. No trace of any plant could be found which corresponded with any one of the many forms which characterise the Mesozoic coal measures so widely distributed throughout Tasmania.

The only difference discernible between the species of *Gangamopteris* and *Glossopteris* found in the Mersey Basin and at Adventure Bay is that in the latter place they appear to be very much more dwarfed. But these features are not of much value as the neuration, form, and size of the various species of these genera are remarkably variable in the Mersey shales. It is worthy of remark that I was unable to discover any trace of *Noeggerathiopsis*, which is commonly associated with *Glossopteris* and *Gangamopteris* in the Mersey Basin, and also in a similar position in New South Wales.

Taking all these circumstances into consideration, I am of opinion that these beds clearly belong to the lower coal measures of Tasmania. Mr. Zschachiner has kindly supplied me with the following information with respect to the two shafts sunk to the coal seam now being worked.

The first or eastern shaft is 90 feet deep, and passes through the following strata:—

Thinly-bedded sandstones and shales	16	0
Brownish sandstone	18	6
Shale	4	0
Thinly-bedded sandstones and shales	20	0
Sandstone	2	6
Shale	0	11
Sandstone	3	0
Thinly-bedded sandstones and blackish arenaceous shales	23	1
Coal	2	0
Total	60	0

Sandstone.

There are numerous curious "jumps" or minor dislocations between the east and west shaft, which latter are 200 yards apart. These faults cause an upthrow and downthrow alternately of about 2 feet; that is about the thickness of the seam. To the west of the last or west shaft there is an important fault, throwing up the coal 32 feet.

The direction of this important fault is very irregular. It appears to have a north and south trend with its underfoot to the east.

West Shaft.

The section of the west shaft which is being worked is as follows:—

Sandstone	15	0
Shale and sandstone...	20	0
Shale	3	6
Sandstone	2	6
Sandstone and Shale...	29	0
Coal	2	0
	73	0

Sandstone.

The coal measure basin is of limited extent, following the lower levels between the greenstone ridges, and following in the direction of the South-western Coast. If we consider the dip to be continuous for the two miles over which the beds are exposed, it is probable that the whole formation does not exceed 800 feet in total thickness. Some of the members appear to contain fair sandstones for building purposes.

One Tree Point.

An interesting section of the marine mudstones is exposed at One Tree Point, North Bruni, in cliffs varying from 70 to 300 feet in height.

The beds dip as usual to the west, and are for the most part composed of regular thin layers of grits, conglomerate,

limestones, and arenaceous mudstones of a white and yellow colour. The members at the base, on the sea margin, consist of grits interlaminated with bands of conglomerate, among which scarce a trace of animal life can be observed.

Waterworn and angular fragments of granite, altered slates, porphryies quartzites, and greenstones (rocks unknown in the vicinity) are most abundant. Some of the blocks are huge like those found by me some years ago underneath the Eurydesma and Pachydomus beds at Darlington, Maria Island.

At the time I described the Maria Island formation, it will be remembered that I was inclined to ascribe the transport of these great erratic blocks to ice action.

Conglomerates of a similar character occur in, similar formation at Bacchus Marsh (Victoria), Wollongong, and Blue Mountains (New South Wales), Queensland, and in the Talchir boulder-bed, India. It is now of additional interest to find that R. D. Oldham, Deputy-Superintendent of the Geological Survey of India, and Dr. Waagen concur in ascribing the formation of beds, which are the analogues of the Upper Palæozoic marine beds of Tasmania, to the influence of glacial action*. Dr. Waagen's views respecting the existence of a glacial period at the close of the Palæozoic age in India and Australia are of such interest that I am constrained to reproduce some of his remarks. He states :—"The enormous development of boulder beds that have been formed under the influence of the action on this ancient southern continent makes the supposition of very low temperature during those times on that continent an absolute necessity. These low temperatures were not of a local occurrence only, but spread on the whole continent, thus indicating a true glacial period - a glacial period that was in the beginning restricted to the Southern Hemisphere, and only later on spread also to the Northern one."† In the earlier times of the carboniferous period a rather high mean temperature must have prevailed on the Southern Continent as luxuriant forests of carboniferous plants were thriving there, of which the remains have been preserved to us in Australia as well as in South Africa. All of a sudden a considerable lowering of the temperature took place, ice began to be formed in South Africa and India, and all the carboniferous flora was destroyed in these countries, as well as in Australia, by this low temperature. In the meantime in Australia a

*Palæozoic glacial beds of the Salt Range (Waagen), Indian and Australian coal bearing age (Oldham). *Records Geological Survey, India*, vol. xix, pt. 1,

†According to Ramsay there is evidence of a glacial period during the accum.

new flora began to appear—a flora that was suited to support moderate or less temperature. Notwithstanding the ice-covered part of the Southern Continent the flora spread slowly westward from Australia during upper carboniferous and permian times to reach Indian and South African regions." This flora (Glossopteris and Gangamopteris, etc.) was referred to at first as "Mesozoic" types, but very strict investigation has now proved them to have existed in Australasia prior to the close of the Palæzoic era.

Dr. Waagen concludes:—"The Palæozoic fauna and flora was that of warm climates. The organisms composing these were not able to endure great changes in temperature. As then, towards the termination of the Palæozoic times, first in the Southern and later on in the Northern Hemisphere also, the general temperature was considerably lowered, a circumstance which is proved beyond doubt by the frequent occurrence of ice-formed boulder-beds, the whole fauna and flora necessarily perished. It was afterwards replaced by a more hardy set of organisms, which, however, by degrees occupied the place previously taken up by the Palæozoic forms."

These conclusions of Dr. Waagen are worthy of consideration, for the barren conglomerates and mudstones so largely developed above the Fenestella Zone in Tasmania, towards the close of the Upper Palæozoic age, testify of a condition of things which was prejudicial to organic life, and whatever differences of opinion may exist as regards the exact time which the glacial period may have covered, there is no doubt that the hypothesis partly explains the barrenness of the Upper Palæozoic marine beds and the sudden break which locally exists between the lower and upper coal measures.

Returning from this digression to our section at One-Tree Point. I observed above the conglomerate beds a single band of limestone about four feet thick, consisting almost entirely of the fossil remains of *Stenopora ovata*, all the species or which were of an unusually large size. With the exception of silicified trunks of a huge conifer which occurred embedded sometimes in this limestone and sometimes in the conglomerate beds, I could find no trace of any other form of life. One of the fossil conifer trunks was over three feet in diameter. Sections showed the pine structure admirably as well as the numerous regular concentric lines of growth.

From the large number of rings of growth it was evident that the tree was of considerable age when it was entombed in the calcareous mudstones of One-Tree Point.

For one hundred feet above the *Stenopora* band the mudstones were more argillaceous, but devoid of fossils or nearly so.

Variety Bay.

The Variety Bay is a small indentation in the mudstone rocks a little north of Cape Frederick Henry. The cliffs here are typical of the whole series from Trumpeter Bay to Adventure Bay. Unlike the mudstone rocks at One-Tree Point the whole series are richly fossiliferous, like the lower beds at Porter Hill.

The following is a description of the section on the southern side of the bay taken in ascending order:—

		Feet.
1.	Greenstone.	
2.	Hard conglomerates and grits without fossils	4 0
3.	Siliceous limestones and mudstones with occasional casts of *Pleurotomaria Morrisiana*	10 0
4.	Hard, dense siliceous rock, replete with thin layers almost wholly composed of the casts of *Pleurotomaria Morrisiana*	4 0
5.	Silicious limestones with casts of *Spirifera convoluta*; *S. Strzelecki*; *Terebratula sacculus*; *Aviculo-pecten limæformis*, *A. Fittoni*, etc.	12 0
6.	Mudstones finely laminated by the abundance of *Fenestella fossula* and *Protoretepora ampla*; together with other common forms	70 0
		100 0

These beds also dip at an angle of about 15deg. to 20deg. to the west.

The beds regularly flank against the greenstone or overlie it, without disturbing the dip or disarranging the characteristic sequence of the several zones. This is also the general character of the relation of the fossil mudstones with the greenstone base from Blackmans Bay to Adventure Bay, a distance of over 20 miles. No one who studies these sections closely can easily arrive at any other conclusion than that the mudstone rocks are younger than the greenstone axis which they either abut against or overlie. It is upon such evidences as these that I have formed my opinions respecting the age of the Mount Wellington greenstones and its lateral spurs, and not upon the mere evidence of the bore test at the Cascades, although I regard the latter as favourable to the views which I am inclined to take at present.

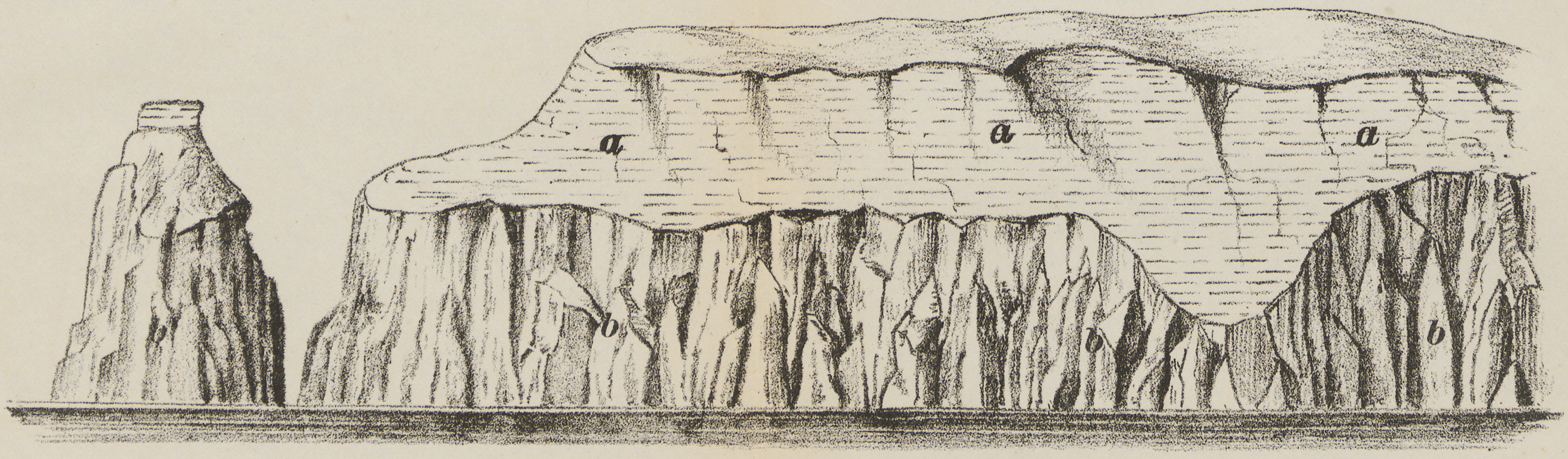
I am not surprised that my friend, Mr. Stephens, should express such confidence in assigning a more recent date to the greenstones of Mount Wellington when he has succeded in satisfying himself that the presence of pyrites and calcite in the overlying mudstones and limestones can only be due to the supposed intrusion of a mass of greenstone which has been proved not to have penetrated within 519 feet of the present surface of these greatly denuded mudstones.

Geikie, who is no mean authority, states that layers of

calcite with brucite are quite characteristic of limestones found among areas of regional metamorphism where no visible intrusive rock has influenced the phenomena, while pyrites is common in all limestones, and is most widely distributed in all kinds of rocks, especially so in certain coal seams. As for myself, I cannot pretend to speak with such confidence as Mr. Stephens upon such a difficult question. I can only state that I have carefully considered the evidences, and have taken much time and trouble to gather and weigh all facts bearing upon the subject, including the facts and arguments of my friend. But notwithstanding this, I can only still affirm that the opinions advanced by me have merely the force of probability in my mind, from which all doubt has not yet been wholly removed.

The dynamical forces which upheaved and dislocated the stratified rocks on the flanks of our mountain chains operated probably at different intervals during a long course of time, in which movements the mountain chains themselves would also partake. There is abundant evidence throughout Tasmania of the eruption of intrusive greenstone rocks of more recent date than the mesozoic stratified rocks, but that is no reason for assuming that all the greenstone masses are of more recent date than the marine mudstones which so frequently abut and overlie the older diabasic rocks of Tasmania. Nor have we a right to assume that all movements of elevation are immediately due to superficial intrusion of igneous rock. Few mountain chains have been produced suddenly by cataclysms, and while I do not deny that cataclysms and intrusive rocks have operated largely in producing important modifications on the earth's surface, I am still inclined to believe that the more important movements which have resulted in raising stratified rocks to immense heights above sea level, as on our mountain tiers, are often intermittent, slow, and cover a vast period of time.

It is hoped that the information now produced with respect to important sections on the East Coast of North Bruni may be of service in arriving at more satisfactory conclusions in all matters to which they relate. I am only anxious for the truth of my opinions, and therefore shall always be prepared to modify them in accordance with the weight of available evidence.



SECTION AT CAPE FREDERICK HENRY.

a. Upper Palæozoic Marine Beds.

b. Diabasic Greenstone.

SECTION AT VARIETY BAY.

d. Fenestella zone
c. Spirifer zone
b. Pleurotomaria zone
a. Grits and conglomerates devoid of fossils

} *Unaltered at points of contact with greenstone.*

(e) Diabasic greenstone.

SECTION AT VARIETY BAY.

a. *Upper Palæozoic Marine Beds.*

b. *Diabasic Greenstone.*